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Biggest Blast in Cosmos Reveals Its Dark Heart

By JOHN NOBLE WILFORD

NASHVILLE, May 28 — While taking X-ray pictures of flares from the Sun in December, a scientific spacecraft happened to detect a tremendous blast of gamma rays from several billion light-years away. The observation, astronomers say, showed the driving force behind what appear to be the most powerful explosions in the universe.

In a report here today at a meeting of the American Astronomical Society, researchers from the University of California at Berkeley said the coherence and alignment, the polarization, of the gamma radiation implied that the tremendous burst of energy originated from a region of highly structured magnetic fields.

The large-scale field, the scientists said, was being generated by the rapid rotation of the extremely dense core object, a black hole or a neutron star, remaining after the explosion of a huge star.

The polarization of the high-energy radiation from the explosion, Dr. Steven E. Boggs of Berkeley said, "is telling us that the magnetic fields themselves are acting as the dynamite driving the explosive fireball we see as a gamma ray burst."

Gamma ray bursts, first detected serendipitously in 1967 by an American space satellite that was monitoring compliance with the 1963 atmospheric nuclear test-ban treaty, were long one of the most intractable mysteries in astronomy. A burst flashes about once a day in different places in space, shines brightly for a brief time and then fades into a lingering afterglow.

Only in 1997 did scientists convince themselves that, luminous as they are, the bursts come from far beyond Earth's galaxy, the Milky Way. Their sources were then identified as extremely large stars, many times as massive as the Sun, that collapsed and exploded with much more force than the usual supernovas.

Now, other astronomers agreed, the spacecraft findings have apparently solved the physics of how some exploding stars produce such tremendous bursts of gamma rays, the most powerful in the electromagnetic spectrum.

"This is definitely a milestone," said Dr. Chryssa Kouveliotous, a specialist on gamma ray burst who was not involved in the research. She is an astronomer at the Marshall Space Flight Center of NASA in Huntsville, Ala.

Another independent astronomer, Dr. Donald Lamb of the University of Chicago, said the discovery was "just absolutely astounding."

A detailed report of the findings by Dr. Boggs and Dr. Wayne Coburn, a Berkeley researcher, was published last week in the journal Nature. In an accompanying commentary, Dr. Eli Waxman of the Weizmann Institute of Science in Israel said the research might "shed light on the identity of the sources of gamma ray bursts, as well as on the mechanism by which the gamma rays are produced."

But Dr. Waxman said it was too soon to rule out the possibility that the polarization "might also arise in a randomly oriented magnetic field." Further research and theoretical analysis is needed, he said.

Dr. Boggs conceded that his interpretation would not be fully accepted until the phenomenon of a polarized gamma ray beam was observed from other bursts. That may not be easy. Although several hundred bursts occur each year, many are too distant and dim for such analysis, or they are observed well after they have faded. And a spacecraft would have to be in just the right position to catch the burst in its field of view.

A European spacecraft, launched in October, has two gamma ray instruments, and their software is being modified to make them sensitive to polarization.

The Berkeley discovery was made by the Rhessi satellite. Launched early last year, it is operated by Berkeley scientists for the National Aeronautics and Space Administration. Though primarily an X-ray observatory, the satellite is also equipped to detect gamma rays.

On Dec. 6, the satellite picked up a flood of gamma rays from a burst, designated GRB021206. The burst peaked for about 6 seconds and then faded over 30 seconds. The measured gamma rays, the scientists reported, were 80 percent polarized, about the maximum possible polarization from electrons that spiral around magnetic fields.

"It is very surprising that this is so highly polarized," Dr. Coburn said. "It is difficult to imagine how you can have an area of very aligned magnetic fields when there is a massive supernova explosion going on and stuff flying all over the place."

Most gamma ray bursts occur at distances of 8 billion to 10 billion light-years. But on March 29, astronomers detected the closest one yet known, at 2.6 billion light-years, close enough for unusually detailed study.

In other reports at the meeting, radio astronomers said they could precisely measure the expanding shock wave from the close burst. They found that the expansion was at nearly the speed of light, as predicted in the standard "fireball" model of the immediate aftermath of a burst. And as the wave expanded, the center of the observed radio emissions did not change position, also as predicted.

In an alternative model, scientists proposed that matter was being shot out of the explosion in distinct concentrations like cannonballs. If so, the motions of such an outflow would be detectable in the radio emissions.

But they were not, Dr. Dale A. Frail of the National Radio Astronomy Observatory in Socorro, N.M., said. The findings not only supported the standard model, he said, but are also "sufficient to rule out predictions of the cannonball model."

The close March 29 burst also afforded the Hubble Space Telescope a bright photographic target for its advanced survey camera. Dr. Andrew Fruchter of the Space Telescope Science Institute in Baltimore said the burst was in a relatively small galaxy, 5,000 light-years wide, that appeared to be a breeding ground of young and especially massive stars. It is just the sort of place, astronomers are finding, where stars explode with gamma ray ferocity.